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T wave changes and postinfarction angina pectoris predictive of recurrent myocardial infarction

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SUMMARY The predictive value of angina pectoris and T wave changes was studied prospectively in 177 consecutive cases with acute myocardial infarction. A total of 21 reinfarctions developed within three months. In 11 of them (52%) at least one electrocardiogram recorded while in hospital showed a steeply ascending limb of the negative T wave, compared with 20 (13%) of those who did not reinfarct. Twenty-one patients had recurrent angina pectoris at rest during the hospital stay, and 10 of them (48%) developed a reinfarction within three months. When combining the electrocardiographic criteria and recurrent angina at rest, 14 of the 21 (67%) reinfarctions were correctly predicted, and 30 of the 156 (19%) patients not developing a reinfarction were falsely predicted.

Many clinical factors are known to predict a high risk of death after an acute myocardial infarction,[1–5] but only some[6] predict a patient at high risk of reinfarction.

In a retrospective series a steeply ascending limb of the negative T wave during the postinfarction hospital stay correctly predicted about 40 per cent of the reinfarctions that occurred within three months. The false positive predictions were 6 per cent. There was also in the same patients a tendency towards a higher incidence of postinfarction angina pectoris among those who later developed a reinfarction. As postinfarction angina, however, had not been systematically registered no conclusion could be drawn.[7]

In this prospective consecutive series of patients with acute myocardial infarction the predictive value of a steeply ascending limb of a negative T wave and angina pectoris in the postinfarction period was studied.

Patients and methods

All patients having acute myocardial infarction during the 12 months between 1976 and 1977 who survived the stay in the coronary care unit were included. The diagnosis of acute myocardial infarction and reinfarction was based upon: (1) prolonged chest pain, frank pulmonary oedema, or syncope; and (2) the appearance of an abnormal Q wave or R wave progression and/or localised ST elevation followed by T wave inversion; and/or (3) two raised serum aspartate aminotransferase (S-AST), with a maximum about 24 hours after onset of symptoms in association with lower serum alanine aminotransferase (S-ALT); (4) findings at necropsy of myocardial infarction at the stage corresponding to the onset of symptoms.

A standard 12 lead electrocardiogram was re-

Fig. 1 *Critical T wave angle in predictive leads.*

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corded every morning for three days and then twice weekly. After the CCU period, leads CR1, CR2, CR3, CR4, CR5, and CR7 were recorded immediately after the recording of V1–6. An ink jet recorder (Mingograf 61 or 81, Siemens-Elema, paper speed 50 mm/s, 1 mV=10 mm) was used. The chest electrode positions were marked out on admission to be kept constant.

Table 1 *Day of first electrocardiographic prediction*

Day	*2–5*	*6–10*	*11–14*	*15–*
Number of patients	15	11	3	2
Number of reinfarctions	6	3	0	2

Electrocardiograms without atrial fibrillation/flutter, bundle-branch block, pre-excitation (WPW), and left ventricular hypertrophy were studied for a negative T wave in leads II, CR4, and/or CR7. In such T waves the angle between the ascending limb and the vertical plane was measured (Fig. 1). If this angle was $\leqslant 55°$ in lead II, $\leqslant 35°$ in CR4, and/or $\leqslant 40°$ in CR7 and no abnormal Q wave or abnormal R wave progression in the same lead was present, the electrocardiogram was considered predictive of a recurrent acute myocardial infarction within three months.[8]

The incidence, duration, and type of angina pectoris were recorded daily until discharge from hospital.

The significance of differences between mean values was tested by Student's t test. The χ^2 test with Yates' correction was used to test differences between relative numbers.

Results

ELECTROCARDIOGRAM

Of 178 patients with acute myocardial infarction who survived the CCU period, all but one were followed after discharge from hospital. Twenty-one of them developed a reinfarction within three months. In 28 of the 177 cases the electrocardiogram showed atrial fibrillation/flutter, bundle-branch block, Wolff-Parkinson-White syndrome, or left ventricular hypertrophy and could not be analysed with reference to the T wave. Among the remaining 149 cases, 19 developed a reinfarction within three months.

In 31 cases the electrocardiogram at some time during the stay in hospital (mean 11 days) fulfilled the criteria predictive of reinfarction, in two patients twice and in one patient on three occasions (Table 1).

Reinfarction occurred within three months in 11 of 31 cases (35%) fulfilling the electrocardiographic criteria compared with eight (7%) of 118 not fulfilling them ($p < 0{\cdot}001$) (Table 2).

In most predicted patients the criteria were fulfilled in lead CR4 (25 of 31) and reinfarctions followed in eight (Fig. 2). In lead II the criteria were fulfilled in 11 cases, with three reinfarctions following. In lead CR7 the criteria were fulfilled in four cases, in which three reinfarctions occurred.

Lead CR7, however, did not predict any reinfarction that was not predicted by lead CR4 or II (Fig. 2). Eight of the 11 reinfarctions were localised to the same left ventricular wall as was represented by the predicting lead (II for the inferior, CR4 for the anterior, and CR7 for the lateral wall). In one case the reinfarct could not be localised.

CR4 was closely correlated with V4 ($r=0{\cdot}95$

Table 2 *Clinical characteristics in patients with analysable T waves*

	Predictable reinfarction (n=31)	*Patients without electrocardiographic criteria (n=118)*	
Age (y, mean ±SD)	62 ±10	62 ±14	NS
Women (%)	27	21	NS
Previous acute myocardial infarction (%)	50	35	NS
Previous angina pectoris (%)	55	45	NS
Diabetes mellitus (%)	14	14	NS
Hypertension (%)	32	24	NS
Anterior acute myocardial infarction (%)	55	40	NS
Inferior acute myocardial infarction (%)	41	32	NS
Transmural acute myocardial infarction (%)	59	55	NS
S-AST maximum (μkat/l)	2·77 ±1·76	3·69 ±2·69	NS
Reinfarction (%)	35	7	***
Mortality from reinfarction (%)	55	25	NS
Three month mortality (%)	23	9	NS
Necropsy (%)	100	80	NS
Necropsy or clinical observation until death (%)	100	100	NS

NS, not significant. ***$p < 0{\cdot}001$.

n=51) though the angle for a given patient tended to exceed the CR4 angle for that patient, so that, for example, a CR4 of 35 might correspond approximately to a V4 of about 40. The correlation between CR7 and V6 seemed, however, much less close (r=0·48, n=39) (Fig. 3).

POSTINFARCTION ANGINA PECTORIS

All patients were asked daily about chest pains during their stay in hospital. This symptom occurred in 48 of the 177 patients.

Twelve of the 48 patients (25%) developed a reinfarction during the observation period of three months, as did nine (7%) of the 129 patients without postinfarction angina ($p < 0.01$).

The postinfarction angina was ranked according to type (Fig. 4). Reinfarction followed in one of 11 (9%) with effort angina and in 11 of the 37 (30%) with angina at rest ($p > 0.05$).

Angina at rest was recurrent in 21 cases and was followed by reinfarction in 10 (48%) as compared with 11 reinfarctions in 156 patients (7%) without recurrent angina at rest ($p < 0.001$).

ELECTROCARDIOGRAM AND ANGINA PECTORIS

Forty-four patients either fulfilled the electrocardiographic criteria predictive of recurrent acute myocardial infarction *or* had recurrent angina at rest (Fig. 5) and reinfarction followed in 14 (32%). Thus, these alternative criteria would have correctly predicted 14 of the 21 reinfarctions (67%) in this series and falsely predicted 30 of the 156 patients (19%) not developing a reinfarction within three months.

The combined criteria, a steeply ascending limb of the negative T wave *and* recurrent angina at rest, would have correctly predicted seven reinfarction cases and falsely predicted one. Fourteen reinfarctions were unpredicted by these combined criteria.

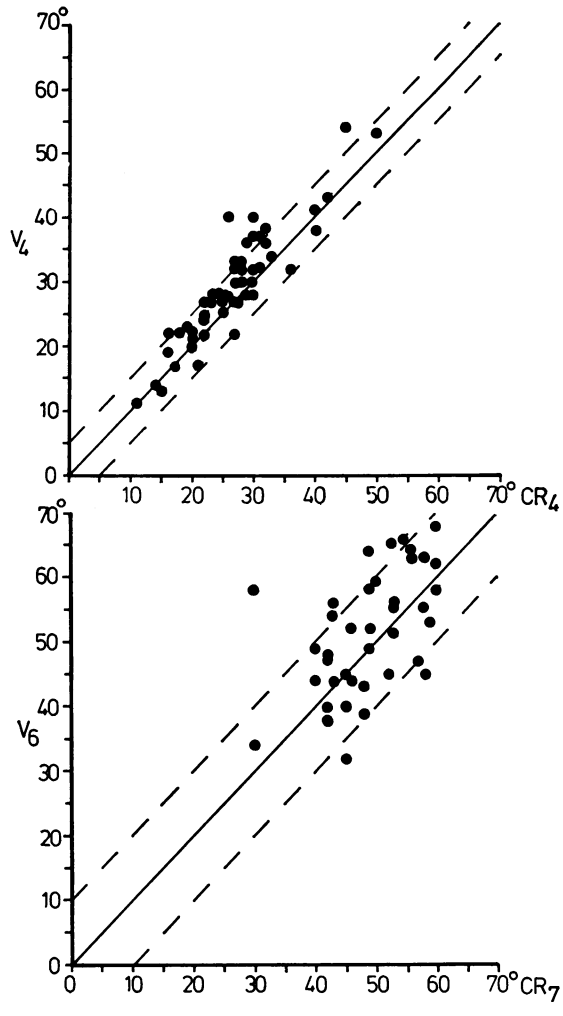

Fig. 3 *The relation between the T wave angle in CR4 and V4 (top, identity line ±5°) and between CR7 and V6 (bottom, identity line ±10°).*

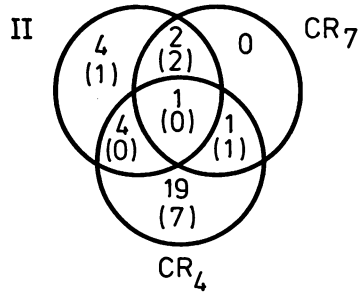

Fig. 2 *Number of predictions made by lead II, CR4, and CR7, respectively. Figures in brackets=number of reinfarctions.*

Discussion

The CR leads have been used in this study as they were the ones in use in Sweden until recently.

The incidence of reinfarction may vary with such things as patient material, diagnostic criteria, and treatment programme, but 12 per cent in the first three months, as in this series, is in accordance with other Scandinavian series.[5 9]

Many clinical factors known to predict mortality after an acute myocardial infarction[3 4 10–13] have

either not been tested or have turned out to be ineffective as predictors of reinfarction.[5] The indices predicting early or later mortality have usually, as in this series, been obtained during the first days or weeks of the acute myocardial infarction. They include age, sex, previous history, extent of the acute myocardial infarction, the presence and severity of heart failure, cardiac rhythm, and the nature and extent of electrocardiographic changes. One study[5] attempted but failed to predict reinfarction using certain indices: first infarction (in men), breathlessness at onset of symptoms, AST quartile, left heart failure, relative heart size, and atrial fibrillation, though they were able to predict cardiovascular mortality within two years of the acute myocardial infarction. In addition, in the present study most of the indices mentioned were studied, but none could predict reinfarction reliably. Only one of the studies[4] analyses changes in the RT segment and T wave but they were given the lowest prognostic significance of mortality and were not tested against reinfarction.

Stenson *et al.*[6] have attempted to predict reinfarction by means of the electrocardiogram. They observed that six out of nine patients with recurrent postinfarction angina and simultaneous transient ST segment elevations experienced a recurrent acute myocardial infarction within six weeks. This result could be compared with the combined result of the present study regarding symptoms, signs, and the small number of patients.

In the placebo group of the Coronary Drug Project,[14] a correlation was found between negative

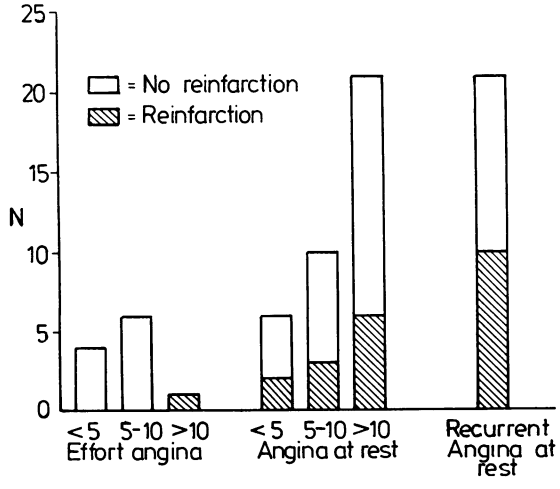

Fig. 4 *Type and duration (in minutes) of angina pectoris during the postinfarction hospital stay.*

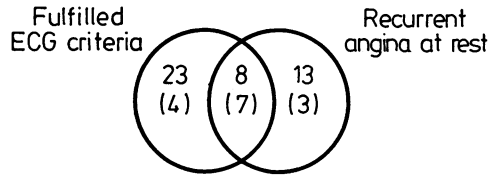

Fig. 5 *Number of acute myocardial infarctions with fulfilled electrocardiographic criteria and/or recurrent angina at rest during the postinfarction hospital stay. Figures in brackets = number of reinfarctions.*

T waves on the electrocardiogram and total mortality and sudden death three months to three years after the acute myocardial infarction but not with reinfarction, despite the fact that 81 per cent of the mortality was attributed to coronary heart disease. The findings of the Coronary Drug Project cannot, however, be directly compared with the present study as it starts at three months when the present study ends.

The mechanism leading to an early reinfarction is unclear, but continued myocardial ischaemia seems a reasonable hypothesis. Angina pectoris is a symptom of continuing myocardial ischaemia as is probably a negative T wave after an acute myocardial infarction.

Measuring the angle between the ascending limb of a negative T wave and the vertical plane was initiated in a retrospective series by visual comparison of electrocardiograms (placed side by side) from a group of patients with reinfarction and a group without reinfarction.

The electrocardiographic criteria predictive of recurrent acute myocardial infarction find about half of the reinfarctions (11 out of 21 or 52%), and about one-third of the predicted patients (11 of 31 or 35%) will reinfarct in three months. This agrees with the findings in the retrospective series.[8]

Adding the alternative criterion, recurrent angina at rest, increased the number of correct predictions from 11 to 14 and the number of false prediction from 20 to 30. Thus, the alternative criteria increase the sensitivity but with some loss of specificity.

There is a difference in the three month mortality between the group showing T wave changes and those without this, but it is not statistically significant ($p > 0{\cdot}1$).

In summary, these criteria predicted that 25 per cent of all patients with acute myocardial infarction surviving the CCU would reinfarct within three months. One-third of the patients developed an infarct. This makes it possible to follow a group of patients for a time in order to note different factors

that may have pathogenetic importance in the reinfarction process. This prediction also makes preventive trials against reinfarction become positive in a smaller series of patients than if no selected studies are performed.

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